A STUDY ON SELECTED PHYSIOLOGICAL VARIABLES OF DIFFERENT SPORTS PERSONS".

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The field of sport gives many golden opportunities to the people to make use of their potentiality, to identify talents, gives experience of winning and losing and also gives enjoyment. Now a days, sports is fiercely competitive event, several factors affect the sports life such as anatomy and physiology, biomechanics, sports training and coaching, sports medicine, nutrition, growth and development, sociology, computer application and psychology and so on. To achieve at international level in the field of sports there should be a spotting of talent, fitness and scientific method of training. The outstanding achievement of an athlete is the combination of several factors such as genetics, health status, training, and skill level, physiological, biomechanical and psychological factors. (Warren et al, 2010). Many nations want to show their supremacy in the field of sports. This feeling of the nations has motivated and inspired the athletes to strive and sweat, to run faster, greater agility and flexibility, explore greater strength, endurance and skill in the competition.

Sport is very competitive and aggressive in nature and each athlete of different sport struggles to better the past records, the records of different sports are cracked more fast nowadays. The coaches are also constantly striving to improve the performance of their athletes by adapting suitable training methods. The extensive knowledge of exercise physiology builds a strong basis for professions like Teaches of Physical Education, coaches of different sports, experts of fitness etc. concerned with sports or exercises of physical activity. Now a day there are several advanced exercise physiology equipment's, bio-mechanical and psychological apparatus available to do experiment. It helps to physical education teachers, coaches and fitness experts to obtain and disseminate knowledge relating to physical activity or exercise of human beings. Furthermore, it aids in scientifically building and executing exercise/workout plans for the sports person of different sports.

1.1. EXERCISE PHYSIOLOGY:

Exercise physiology is studying the function of the human body under the pressure of chronic and acute exercises. "It is also concerned with how the human body reacts to

the intense demands located on it by sport or exercise or physical activity and the changes that happen in the body as individuals regularly participating in sports training". (Brown et.al., 2006).

Exercise physiology is both scientific discipline and applied science. As a sub discipline of physical education, it is concerned with study of cardio-vascular, neuro-muscular and metabolic process and also studies the effect of exercises on them. It is also involving the study of source of energy for movement, the process of energy generation and the effects that movement has on the systems of body.

Exercise physiology is eclectic in its content, methodology and practices not only physiology but also involving nutrition, psychology, biochemistry, endocrinology. While cardiopulmonary fitness is an important objective of exercise physiology, it is just one aspect of the sub discipline. It is also concerned with exploring how efficiently energy is used. Researchers observe and record data of body under exercise stress and learn much about the dynamics of respiratory, cardiovascular and muscular systems. Result of the studies reveal the adaptation of the body to exercise and provide ample data ascertains the benefits accruing as a result of such training. Research and measurement techniques can know ascertain the respiratory exchange ratio as well as the amount of energy obtain from various fuel sources. The hall mark of exercise physiology is what happens to the human biologic system under the stress of exercise- human movement.

Regularly participating in sports and sports training makes several differences in the physiological status of a person. The body changes its many physiological functions for adaptation to the exercise. Various physiological variables influence the sports performance. Like those variables that influence performance are VO2max, the anaerobic threshold, RER, heart rate, minute ventilation, anaerobic power, economy of running and etc. Several of these physiological parameters can distinguish among highly trained and untrained athletes. Though, within the skilled. population there is significant variability for each. For instance, highly skilled athletes have a tendency to have higher VO2 max values than inexpert individuals. These high VO2.max values are somewhat answerable for the endurance performance of the highly skilled runner. The similar cannot be said

about a group of extremely trained athletes: the person with the highest VO2 max values are not necessarily the best runners, nor vice versa. There are many instances in the literature of outstanding athletes with modest VO2 max values or relatively untrained individuals with outstanding VO2 maxvalues. This maybe evident that physiological parameters take special thoughts and vital pre-requisite for owing performance in sports.

Lawrence et. al., (1976), have highlighted that the scientific study of exercise physiology is turning out to increasingly significant with increasing realization of connection of exercise to health. "…. Laboratory and field observations on exercising human subjects are being enhanced with physiological and biomechanical studies in laboratory animals with the results of many of phenomena associated with acute and chronic exercise can now be explained at cellular and molecular levels". The improvement of physical efficiency for various kinds of sports and games is of extraordinary importance and requires a lot of selectivity, specificity and exercise. Through the usage of these methods, the sportspersons of the developed nations have reached a very high level of expertise. Thus, physiological assessment helps the athletes, competitors, sports persons and coaches in numerous ways.

1.2.DESCRIPTION OF SELECTED PHYSIOLOGICAL VARIABLES:

1.2.1. CARDIO-PULMONARY EXERCISE TEST (CPET) UNIT:

There are several methods to assess the cardio-pulmonary parameters during exercise, but most relayed method is breath-to-breath analysis method because it gives the best assessment of the metabolic response to the exercise. (Albouaini et al., 2007, Mazaheri et al., 2021). The cardio-pulmonary exercise testing (CPET) asses the physiological response of the cardiovascular, "pulmonary, muscular and cellular oxidative system" to exercise. (Guazzi, 2017, Mazaheri et al., 2021). "Cardio-pulmonary exercise testing (CPET) permits the most reliable and reproducible measurement of cardiorespiratory fitness and performance in athletes. It provides functional physiologic indices which are key variables in the assessment of athletes in different disciplines. The CPET assess the consumption of oxygen, production of carbon dioxide and other

ventilatory efficiencies during incremental exercises". (Albouaini et al., 2007, Mazaheri et al., 2021). Although, the cardio-pulmonary exercise testing (CPET) has develop a well-accepted method to measure the physiological adaptation to the regular chronic exercise, "…..its valuable applications for more comprehensive assessments in the athletic population are not universally widespread yet". (Mazaheri et al., 2021). The influence of physiological parameters to the sports performance are discussed below;

1.2.2. MAXIMAL OXYGEN UPTAKE (VO_2 MAX):

The concept of Maximum oxygen uptake (VO2 max) was foremost proposed by Hill et al. in the year 1923, "….it is the highest rate of oxygen uptake and utilization by the body during intense, maximal exercise that no further increases in work rate bring on additional rises in VO2 (i.e., plateau)". (Mazaheri et al., 2021)

Vo_2 max is the threshold ability of the human body to use and transport oxygen during the exercise. It "…is the maximum oxygen uptake of the human body that defines the maximal amount of energy accessible by aerobic metabolism at peak exercise". (Mezzani, 2017). It is the standard for quantifying the cardiorespiratory fitness and may reflects the limit of the cardiopulmonary structure to maximal exercise. (Mazaheri et al., 2021). The term Vo_2 max implies a person's physiological limit that is attained and continuous for a definite period during maximal effort. Sportspersons of different discipline presents with a wide verity of Vo_2 max and ideal body weight may be entirely different, it is well to express it as percent-predicted value or in milliliter of oxygen per kg of human body weight of a person per minute (ml/kg/min), for the better inter-individual comparison. (Balady et al., 2010, Mazaheri et al., 2021). Many studies have proved that the trained athletes have better Vo_2 max than the sedentary and less trained individuals. The Vo_2 during the recovery after the exercises also should be taken into consideration in athletes is very essential. In highly trained athletes, Vo_2 during the recovery is more rapid and the

athlete with "..the advanced exercise economy takes a faster Vo2 recovery rate than his counterpart with less" effort cardiovascular function. (Mazaheri et al., 2021,).

1.2.3. PEAK OXYGEN CONSUMPTION ($VO_{2\ PEAK}$):

The "peak oxygen consumption (VO2peak) was defined as the maximum attained VO2 at the end of the exercise period, when the subject is exhausted". (Rocco et al., 2012). Peak VO2 (VO_{2peak}), directly reflective of VO2 max, "…is the highest value of VO2 attained upon an incremental or other high-intensity exercise test, designed to bring the subject to the limit of tolerance" (Whipp et.al., 1990). VO2 peak "...is a measure that combines cardiovascular and skeletal muscle oxidative function (i.e., Fick equation: Oxygen Uptake =Cardiac output X Arteriovenous oxygen difference)". (Ross et.al., 2010), "….as well as pulmonary ventilation and diffusion capacity, and reflects the integrated ability to transport oxygen from atmospheric air to the mitochondria to perform work" (Andersen et.al., 1995). "VO2peak is reliably measured by indirect calorimetry during graded, maximal exercise, typically performed on a treadmill or cycle ergometer, and is routinely obtained in the clinic and research settings". (Pivarnik et.al., 1996, Sui et.al., 2007).

1.2.4. RESPIRATORY EXCHANGE RATIO (RER):

The respiratory exchange ratio (RER) is the ratio between carbon dioxide production and oxygen uptake. It is also called as gas exchange ratio. "Respiratory exchange ratio (RER) is used to study human metabolism by measuring the ratio of O2 utilized and CO2 expired to estimate substrate utilization" (Brooks, 1984). For instance, if Respiratory Exchange Ratio is 0.7, then 100% of metabolism is coming from fat, if RER is 1.0 then 100% of metabolism is coming from Carbohydrates (Brooks, 1984), though humans can attain a Respiratory Exchange Ratio above 1 when there is extra CO2 creation measured after bicarbonate buffered acid (Naimark, Wasserman, & Mcllroy, 1964). "RER

increases during exercise owing to either the buffered lactic acid or hyperventilation (usually towards the end of exercise)". (Mazaheri et al., 2021, Albouaini et al., 2007).

1.2.5. MINUTE VENTILATION: (VE)

The amount of air we either exhale or inhale in one minute is termed as minute ventilation. It is the product of tidal volume and respiratory rate. During rest the ventilation ranges between 4-15 L.min.-1. It changes with body size and is smaller females and larger in males. The minute ventilation increases during the exercise, which is followed by a continued, greater increase in the breathing rate and tidal volume. Through exercise up to near maximal intensities, the minute ventilation increases proportionally with an increase in the metabolic demands of the body. Fallowing training, the maximal ventilation is increased. In other words, training helps in an increased efficiency of ventilation.

1.2.6. HEART RATE:

The quantity of cardiac contractions within one minute is termed heart rare. The sum of contractions varies from 60-80 bpm. The rate and force of the cardiac contraction is affected by age, stress, lifestyle, disease, fitness level, long term training, and environmental temperature., however 72 bpm is generally considered as a regular heart rate, however a lower resting heart rate is recorded in the trained individual. Before starting the exercise or competition, the pre-exercise heart rate increases well above resting values. This is also referred as anticipatory response. Studies have noticed a faster heart beat rapidly at the start of an workout. This initial heart beat afterward the exercise is faster than the preceding ones. During sub maximal levels of exercise, when the rate of work is maintained at a constant level, the heart rate increase almost rapidly till it reaches plateau. The plateau is referred as the steady state heart rate. Thus, stable state heart rate is the best heart rate for satisfying the cardiovascular demand at that exact rate of work. With a further increase in the exercise intensity, the heart will approach a new stable state

value within one to two min. but with the exercise becoming more strenuous, a longer time is taken to achieve the steady state level. The heart rate increases directly with a corresponding increase in the exercise intensity, until the subject reaches a point of exhaustion. Immediately after accomplishment of the exercise the recovery of the heart rate begins. In well cardiovascular adapted athletes, the recovery rate is faster.

1.2.7. OXYGEN PULSE (O2 PULSE):

The O2 pulse is the proportion of volume of oxygen uptake in ml per min and heart rate in beats/min. It is expressed as ml/beat. (Myers et.al., 2015). "According to the Fick equation, VO2 = (HR × SV) × C(a-v) O2, where SV is stroke volume and C(a-v) O2 is the arterio-venous oxygen difference. Thus, the oxygen pulse provides an estimate of stroke volume and peripheral vascular perfusion/extraction response to exercise" (Balady et al., 2010, Mazaheri et al., 2021). "Normal values at rest range from 4–6 mL/beat and increase up to 10–20 mL/beat at maximal exercise". (Myers et.al., 2015, Mazaheri et al., 2021). "Athletes demonstrate a 10%–15% increase in ventricular cavity size and enhanced cardiac filling in diastole that augment their stroke volume (SV) compared with individuals of similar age and size". (Sharma et.al., 2015, Gerche et. Al., 2012, Mazaheri et al., 2021). "The increased mitochondrial oxidative capacity and capillarity within the skeletal muscle, which results in higher C(a-v)O2 during exercise". (Roca et.al., 1992, Mazaheri et al., 2021). "…As a result, O2 pulse is higher in trained athletes, but the reference values in this population are yet to be determined". (Mazaheri et al., 2021).

1.2.8. METABOLIC EQUIVALENT (METs):

Metabolic Equivalent is the proportion of working metabolic rate comparative with the resting metabolic rate. Metabolic rate is the rate of energy expended (used) per unit of time. "One METs is the sum of O2 consumed whereas sitting at rest and it is equal to 3.5 mlO2/kg X min". (Jetté et al., 1990). The measuring of METs helps in assessing the energy consumption during physical movement. "A major advantage in the determination

of energy expenditure, which may improve the accuracy of physical action assessment over a broad range of intensity levels". (Warren et al., 2010). The METs concept provides a appropriate method to define the functional Volume or exercise acceptance of a person as determined from advance exercise testing and to describe a variety of physical actions in which a individual may join safely, without beyond a given intensity level.

1.2.9. ANAEROBIC THRESHOLD (AT):

The anaerobic threshold (AT) "…. was determined to occur at the break point between the increase in the carbon dioxide output and VO2 (V-Slope) or the point at which the VE/VO2 reached the minimum value and began to rise without a concomitant rise in VE/VCO2". (Wasserma et.al., 1973). AT "…is expressed as VO2 (mL/kg/min) or percentage of VO2max and compared with VO2max, is better correlated to athletic endurance performance". (Jones et.al,2000, Sarma and Levine, 2016). "… It usually occurs at 45% to 65% of VO2max in healthy untrained subjects". (Balady et.al, 2010, Myers et.al., 2015) "...and at a higher percentage (close to 90% of VO2max) in highly endurance-trained athletes". (Sarma and Levine, 2016).

1.3. DESCRIPTION OF THE SPORTS SELECTED FOR THE STUDY:

1.3.1. RUNNING OF LONG DISTANCE:

Long distance running is form of continuously running over a minimum distance of 3 kilometers. The long-distance running is physiologically, aerobic in nature needs stamina as well psychological strength. "…. Long-distance runners typically perform at around 75–85% of peak aerobic capacity, while short-distance runners perform at closer to 100% of peak" (Zinner et.al., 2015). The lactate threshold capacity in long distance runners is good it is correlate to their performance.

1.3.2. JUDO:

Judo is an unarmed combat sport. It Is turning into an official sport occasion in the Olympic Rounds of Munich in 1972 for men and in the 1992 Games (Barcelona) for ladies (Global Judo Alliance). In the 1964 Games, judo was welcomed in Tokyo for men, while the equivalent occurred for ladies in the 1988 Games (Seoul). In 1961, there were big showdowns in Paris. The first contest with weight classifications occurred in the 1964 Games (Tokyo), including three classifications and an open, while in 1965 (Rio de Janeiro), five classifications and an open were remembered for the program.

Cutthroat judo requests extreme focus discontinuous activities, in which ideal actual traits are fundamental to accomplish specialized strategic turn of events and outcome in battle Really, high preparation loads, which require fruitful and facilitated activities, are applied to judokas to accomplish high game's presentation. Since judo is a game including weight classifications, a significant preparation objective is the accomplishment of an ideal load through the mix of confined diet and vigorous preparation, as a rule intending to quickly diminish fat mass.

As indicated by a few investigations, there are judokas who can lose somewhere in the range of 3% and 6% fat mass during the last a long time before the opposition. This reduction could arrive at even 10% of weight trying to get a benefit by contending with lighter, more modest and more vulnerable adversaries. Judo mentors and judokas ought to have a strong information about physiological reactions to contests and physiological variations to preparing to plan a sufficient instructional meeting and season.

1.3.3. **HOCKEY**:

Field hockey is a game with a long history that has gone through very fast and revolutionary change in the previous 10 years. The appearance of the synthetic playing surface has changed the tactical, specialized, technical strategic and physiological prerequisites of the game at all levels. In order to handle with the practical evolution inside the game the hockey player has also had to grow physiologically to encounter the physical values required at top levels.

"The game of hockey at the top level is essentially a low-intensity activity, interspersed with varying bouts of high intensity activity". (Lythe and Kilding, 2011). "The successful player requires muscular endurance, strength, power, skill, psychomotor attributes and cardiovascular fitness". (Reilly & Borrie, 1992).

Hockey has highly required the all 3 energy systems. In which aerobic system is significant during prolonged intermittent workout, and high intensity activities rely on the anaerobic energy systems, adenosine triphosphate. phosphocreatine for the middle and anaerobic glycolysis for short term.

"The overview of artificial turf has transitioned the game to be more physiologically demanding" (Reilly & Borrie, 1992). "With quicker ball movement play accelerates" (Malhotra et al., 1983); "…. there are more touches per possession and greater time dribbling, leading to increased skill level and tactical play. The rule changes of unlimited interchange and no off-side, has led to less disruption in play, and greater player movement, requiring a greater level of fitness". (Reilly & Borrie, 1992).

Identification of the physiological qualities of an athlete in a given sport discipline helps in the player's selection process and identifying athletes' strengths and weaknesses; furthermore, leads to the development of sport-specific training and testing. (Cox MH et.al., 1998). Hence, assessing the status of selected physiological variables among the different sports person and a careful analysis of assessed each variable may help the coaches and athletes to understand the future performance and fix the target. And also helps the coaches and trainers to train the athletes to their optimal level, to get more advantage of training, and helps to get better result at the earliest.

1.4. STATEMENT OF THE PROBLEM:

The purpose of the study was examine, analyze and comparing the selected physiological variables among different sports persons.

1.5. DELIMITATIONS OF THE STUDY:

1. The study was delimited to the selected physiological variables i.e.;

i. Absolute Peak Vo_2.
ii. Relative Peak Vo_2.
iii. VO_2 at Anaerobic Threshold (ml/min).
iv. Respiratory Exchange Ratio (RER).
v. Metabolic Equivalents (METs).
vi. Energy Expenditure.
vii. Minute Ventilation (VE).
viii. Heart beat at Anaerobic Threshold.
ix. Exercise Heart Rate.
x. Recovery Heart Rate.
xi. Oxygen Pulse.

2. The study was restricted to male subjects.
3. The study was confined to 20-24 years of subjects.
4. For the study, the total 60 different sports persons were selected from three different sports that was Long Distance Running (n=20), Judo (n=20) and Hockey (n=20).

1.6. LIMITATIONS OF THE STUDY:

1. CPET unit was used with the treadmill to examine the physiological variables of the study, this would be a limitation.

2. The exercise protocol was constructed with the help of exercise physiology experts for each individual athletes of selected sports, this would be a limitation.

3. Since no consideration was given to the selection of the subjects on the basis of their achievement except national and/or University level competitions, the undulation in the status of the sample may also be considered as a limitation.

4. The previous training structure, load dynamics (intensity, duration and repetition) and food habits of the players were not considered while assessing the variables.

5. Geographical background was not controlled.
6. Due to the COVID-19, many of the athletes were refused to give data, it was one of the limitations.
7. No motivational techniques were used to gather the data.

1.7. OBJECTIVES OF THE STUDY:

1. To examine and compare the Absolute Peak VO2 of Long-Distance**.** Runners, Judo and Hockey players.
2. To examine and compare the Relative Peak VO2 of Long-Distance Runners, athletes of Judo and Hockey players.
3. To examine and compare the VO2 at Anaerobic Threshold of Long-Distance Runners, Judo and Hockey players.
4. To examine and compare the Respiratory Exchange Ratio (RER) of Long-Distance Runners, Judo and Hockey players.
5. To examine and compare the Metabolic Equivalents (METs) of Long-Distance Runners, Judo and Hockey players.
6. To examine and compare the Energy Expenditure of Long-Distance Runners, Judo and Hockey players.
7. To examine and compare the Minute Ventilation (VE) of Long-Distance Runners, Judo and Hockey players.
8. To examine and compare the Heart Rate at Anaerobic Threshold of Long-Distance Runners, Judo and Hockey players.
9. To examine and compare the Exercise Heart Rate of Long-Distance Runners, Judo and Hockey players.
10. To examine and compare the Recovery Heart Rate of Long-Distance Runners, Judo and Hockey players.
11. To examine and compare the Oxygen Pulse of Long-Distance Runners, Judo and Hockey players.

1.8. HYPOTHESIS OF THE STUDY

On the basis of literature review, findings of the previous researches, and the investigator understanding of the problem, the study was hypothesized in following way,

1. It was hypothesized that there would be significant difference in Absolute Peak Vo_2 (l/min) among Long-Distance Runners, Judo and Hockey Players.
2. The study was hypothesized that there would be significant difference in Relative Peak Vo_2 (ml/kg/min) among Long-Distance Runners, Judo and Hockey Players.
3. It was also hypothesized that there would be significant difference in VO_2 at Anaerobic Threshold among Long-Distance Runners, Judo and Hockey Players.
4. The study was also hypothesized that there would be significant difference in Minute Ventilation (VE) among Long-Distance Runners, Judo and Hockey Players.
5. The study was further hypothesized that there would be significant difference in Respiratory Exchange Ratio (RER) among Long-Distance Runners, Judo and Hockey Players.
6. Further, it was hypothesized that there would be significant difference in Metabolic Equivalents (METs) among Long-Distance Runners, Judo and Hockey Players.
7. It was further hypothesized that there would be significant difference in Energy Expenditure among Long-Distance Runners, Judo and Hockey Players.
8. It was hypothesized that there would be significant difference in Heart Rate at Anaerobic Threshold among Long-Distance Runners, Judo and Hockey Players.
9. It was also hypothesized that there would be significant difference in Exercise Heart Rate among Long-Distance Runners, Judo and Hockey Players.
10. It was also hypothesized that there would be significant difference in Recovery Heart Rate among Long-Distance Runners, Judo and Hockey Players.

11. Finally, it was hypothesized that there would be significant difference in Oxygen Pulse among Long-Distance Runners, Judo and Hockey Players.

1.9. SIGNIFICANCE OF THE STUDY:

The standard of sports and physical fitness in our country is average when compare to other sports achieved countries. The lack of scientific knowledge and the use of available knowledge is one of the draw backs. The selection of a suitable activity, the improvement of those aspects exactly demanded by a particular sport are mostly ignored. This in turn act as a limiting factor in terms of highest level of achievement.

Keeping in view the demand of importance of physiological variables for development of sports performance, it was very important to examine the selected physiological variables among difference sports persons, which helps to formulate the fitness development training strategy as per the player's physiological status. The most critical point is to know that, how much training was optimal to bring about the best physiological responses, without causing much Musculo-skeletal problem.

With this background, the present study makes the following contribution;

1. The findings of the present study may provide the guidelines to the teachers of physical education and coaches to frame the long-term training programs according to the specific demands for their respective sport.
2. The study may explain the effect of involvement in different sports on physiological variables to the coaches and athletes.
3. The study would promote enthusiasm and interest among scholars for further investigation in the field of sports.
4. The study may help to know the Physiological status of the players, keeping in opinion the demand for different sport.

5. The study would provide information about status of selected physiological variable and compare them with the elite athletes.

6. The study may also help to find out the potential deficiencies if any and to undertake remedial measures to overcome the training stresses.

7. Add to the knowledge of exercise physiology.

1.10. DEFINITIONS OF TERMS:

Exercise physiology:

Exercise physiology is "a science that elucidates how the human body functions, reacts, adjusts and adapts when exposed to varied degrees of physical activity or training." (Tiwari, 1999).

$VO_{2\ Peak}$:

"The maximum ability of the cardiovascular system to deliver oxygen to exercising skeletal muscle and of the exercising muscle to extract oxygen from the blood". (Hill and Lupton, 1923)

Respiratory Exchange Ratio: (RER)

"The respiratory exchange ratio is the ratio between the metabolic production of carbon dioxide (CO2) and uptake of oxygen (O2)". (Ramos et.al., 2008)

Metabolic Equivalents (METs):

"Metabolic equivalents are defined as the caloric consumption of an active individual compared with the resting basal metabolic rate at rest". (Fernando, 2010).

Energy Expenditure:

"The total energy cost of maintaining constant conditions in the body plus the energy cost of physical activities". (Murphy and Murtagh, 2013)

Minute Ventilation (VE):

"Minute ventilation is the volume of gas inhaled or exhaled from a person's lung per minute". (Wikipedia).

Breathing Rate:

"The respiratory rate is the rate at which breathing occurs; it is set and controlled by the respiratory center of the brain. A person's respiratory rate is usually measured in breaths per minute". (Wikipedia).

Heart Rate:

"Heart rate is the speed of the heart beat measured by the number of contractions of the heart per minute". (Wikipedia).

Oxygen Pulse:

"Oxygen pulse is defined as the ratio of oxygen consumption to heart rate and express the volume of oxygen ejected from the ventricles with each cardiac contraction". (David,2014)

Chapter-II

REVIEW OF RELATED LITERATURE

Review of related literature helps to the investigator in a right way to solve the research problem. The literature gives foundation to any field of knowledge upon which future concept will be construct. In all type of research, the analysis of literature is a part and it gives thorough knowledge to the scholar about the taken study and older similar studies, which helps to the investigator to find out the research gap.

The reviews of related literature give a basic idea to the scholar about characteristics of the subjects, data collecting, testing procedure, selection of statistical techniques and analyze and interpret the results on the basis of studies already done. Moreover, review of related literature helps to understand the scope of the selected study. Review of related literature is also an instrument to select study, methodology and construct the hypothesis of the study.

"The literature in any field forms the formation upon which all future work will be built", (Aggarwal, 1975).

Bhagat & Singh (2021), conducted a study to analyze the VO_2 max in different team games, for the study 120 sports persons from different team games were selected as subjects, in which 30 from each hockey, football, handball and basketball as subjects. Cooper's 12-minute run and walk test was employed to assess the VO_2 max of the subjects. Statistical techniques descriptive and ANOVA was used to analyze the collected data. And The result found that there was a significant difference found among selected team games.

Mazaheri et al., (2021) and Herdy et al., (2016), opinioned that the CPET is the well accepted method to assess cardiorespiratory fitness of the athletes in their review article.

Chapter-III

METHODOLOGY

The methodology chapter explains the Subjects selection procedure, criterion measures, equipment and tools used, Procedure of data collection, reliability of the collected data, administration of the test and statistical techniques of the study.

The purpose of the study was to examine, analyze and compare selected physiological variables status of the sports persons of different sports.

3.1. SELECTION OF SUBJECTS:

The purpose of the study was to analyze and comparing the selected physiological parameters between different sports persons. To achieve the purpose 60 male different sports persons were selected from three different sports that is Long Distance Running (n=20), Judo (n=20) and Hockey (n=20) who have represented University and National level were randomly selected. And the age of the selected subjects was 20 to 24 years. Only healthy, physically fit and volunteers were selected for the study.

3.2. SELECTION OF VARIABLES:

On the basis of review of all the available related literatures, books, journals, encyclopedias, research papers and periodicals relating to the study, the investigator selected the fallowing variables for the study.

3.2.1. Personal Variables:

1. Chronological Age.
2. Height.
3. Body Mass.
4. Athletic experience in years.

3.2.2. Physiological Variables:

1. Absolute Peak VO_2.

2. Relative Peak VO_2.
3. Vo_2 at Anaerobic Threshold.
4. Respiratory Exchange Ratio (RER).
5. Metabolic equivalents (METs).
6. Energy Expenditure.
7. Minute Ventilation.
8. Heart Rate Anaerobic Threshold.
9. Exercise Heart Rate.
10. Recovery Heart Rate.
11. Oxygen Pulse.

3.3. SELECTION OF EQUIPMENT:

To accomplish the purpose of the study the data was collected with the help of Cardio Pulmonary Exercise Testing unit (CPET) with treadmill (COSMED), breath-to-breath analysis with submaximal load.

Table: 3.1. The name of the variables, equipment and unit of measurement.

Sl. No.	Name of the Variable	Equipment	Unit of Measurement
1	Height	Stadiometer	Centimeters
2	Weight.	Weighing Machine	Kilograms
3	Absolute Peak VO2	CPET (breath-to-breath analysis)	ml/min
4	Relative Peak VO2	CPET (breath-to-breath analysis)	ml/min/kg

5	Vo_2 at Anaerobic Threshold	CPET (breath-to-breath analysis)	ml/kg
6	Respiratory Exchange Ratio (RER)	CPET (breath-to-breath analysis)	Ratio
7	Metabolic Equivalent (METs)	CPET (breath-to-breath analysis)	--------
8	Energy Expenditure	Formula Used	Calorie/minute
9	Minute Ventilation (VE)	CPET (breath-to-breath analysis)	L/min
10	Herat rate at Anaerobic Threshold	Polar heart rate monitor connected to CPET Unit	Beat per minute
11	Exercise Heart Rate.	heart rate monitor connected to CPET Unit	Beat per minute
12	Recovery Heart Rate	heart rate monitor connected to CPET Unit	Beat per minute
13	Oxygen Pulse	CPET (breath-to-breath analysis)	ml/beat

3.4. PROCEDURE OF DATA COLLECTION:

To collect the data of the study 60 male trained different sports persons selected from three different sports that is Long Distance Running (LD) (n=20), Judo (JD) (n=20) and Hockey (HK) (n=20).

3.4.1. Orientation to the Subjects:

In order to get full cooperation from the subjects, preceding to the administration of the trial, the investigator was described the purpose of the tests to the selected subjects, their participation during the test program and also explains about the testing procedures of selected variables with the help of the Exercise physiology expert. The subjects were motivated to give their best effort and cooperation to attend the program sincerely. The investigator also got the duly signed consent forms by the athletes that mentioned the acceptance to participate in the particular study's testing procedures.

Figure 3.1: Orientation to the Subjects

3.4.2. Pre-test Screening:

The purpose of the pre-test screening was to identify weather any selected subjects had any medical contraindication to performing the test or had any other health/medical concerns. It was done with the help of Health History Questionnaire and Physical Activity Readiness Questionnaire (PAR-Q).

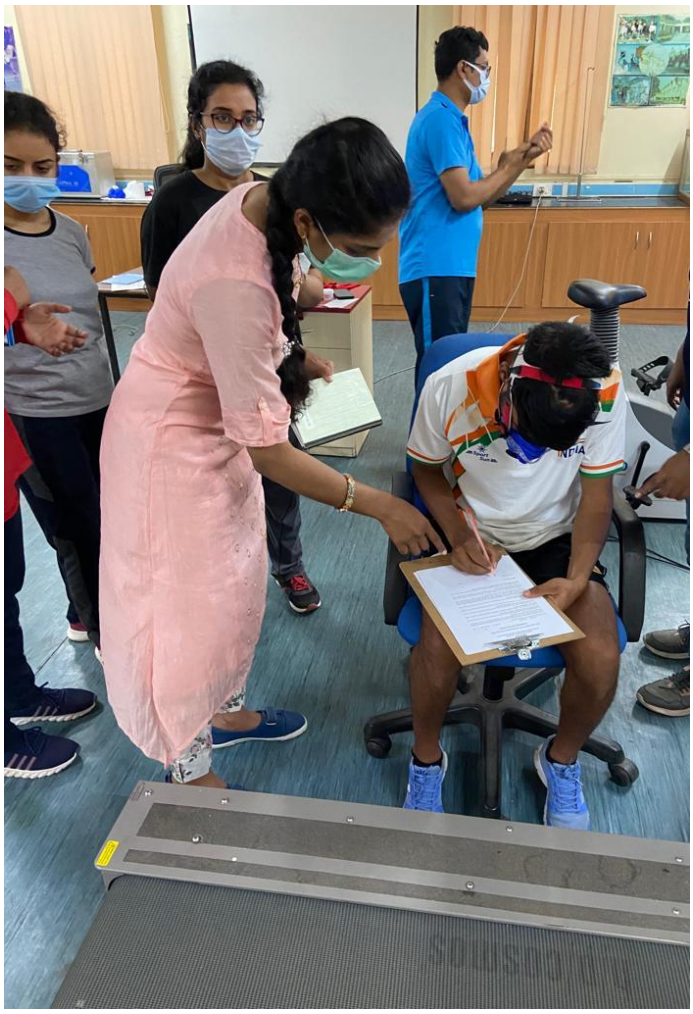

Figure 3.2: Questionnaires filling and signing the consent form by the subject

3.5. RELIABILITY OF THE DATA:

The data's reliability was established, ensuring the instrument's reliability, competency of the tester, tests' reliability and reliability of subjects.

3.5.1. Instrument Reliability:

The equipment used this study was Cardio Pulmonary Exercise Testing Unit (CPET) from COSMED. The manufacturer certified the reliability and accuracy of the instruments.

3.5.2. Tester's Competency:

For establishing tester's competency, the investigator has sufficient practice under the guidance of expert. Some practice sessions were also conducted.

3.5.3. Reliability of the Tests:

The tests' reliability was established by using test-retest method. 6 Subjects were used for test-retest method under the similar condition and same tester had taken the measurement. The reliability of test-retest scores were presented in Table-3.2.

Table-3.2: Correlation of Test-retest scores of Physiological variables of subjects:

Sl. No.	Physiological Variable	Reliability Coefficient of correlation - r value
1	Absolute Peak VO2	0.97
2	Relative Peak VO2	0.97
3	Vo_2 at Anaerobic Threshold	0.96
4	Respiratory Exchange Ratio (RER)	0.96
5	Metabolic equivalent (METs)	0.97
6	Energy Expenditure	0.97
7	Minute Ventilation (VE)	0.97
8	Herat rate at Anaerobic Threshold	0.97
9	Exercise Heart Rate.	0.96
10	Recovery Heart Rate	0.96
11	Oxygen Pulse	0.97

3.6. ADMINISTRATION OF TESTS:

3.6.1. Age:

The chronological age of the subjects was taken from their SSLC documents.

3.6.2. Height:

Purpose: to measure the height of the selected subjects from head to foot.

Equipment: Stadiometer

Method: standing height is the measurement the maximum distance from the floor to the highest point of the head, when the subject is facing directly ahead. Shoes should be off, feet together, and arms by the sides. Heels, buttocks and upper back should also be in contact with the wall when the measurement is made.

Scoring: The measurement was taken in centimeter.

3.6.3. Weight:

Purpose: to measure the weight of the selected subjects

Equipment: Weighing Machine

With the above tests the investigator also gathered the information about the training history of the selected subjects by using a set of questions; those questions related to age of started sports, type of training, training experience and etc. This information might be helps in interpreting the results of the study.

3.6.4. Cardio Pulmonary Exercise Test (CPET):

The breath-to-breath analysis was conducted in CPET Unit from COSMED with different protocol for each selected subject. The protocol was planned with the help of the exercise physiology expert according to the individual athlete's fitness level and the sub maximal load was given during the test. The warm up speed and initial speed was fixed on fitness level of the subject, for every minute the speed was increased to 1 km/hr. 5 minutes warm

up was given for each athlete before the test and given 1-minute active recovery and 2 minutes passive recovery immediately after the test was given. The testing time was 12 minutes running and total time was taken by a subject was 20 minutes for the test.

Smart LAB heart rate monitor was connected to the device to measure the heart rate. The breath-to-breath analysis was done and recorded the data for every 30 seconds. The calibration of gas and turbine calibration was done before testing each athlete. The mask was thoroughly sanitized with alcohol, detergent and water before and after the test of each subject. The following physiological variables were tested with CPET with Treadmill.

1. Absolute Peak VO_2.
2. Relative Peak VO_2.
3. Vo_2 at Anaerobic Threshold
4. Minute Ventilation
5. Respiratory Exchange Ratio (RER).
6. Metabolic equivalents (METs).
7. Heart Rate at Anaerobic Threshold
8. Exercise Herat Rate.
9. Recovery Heart Rate.
10. Oxygen Pulse.

Figure 3.3: Testing of Physiological Variables with CPET on Treadmill.

Figure 3.4: Testing of Physiological Variables with CPET on Treadmill.

Figure 3.5: Testing of Physiological Variables with CPET on Treadmill.

3.6.5. Energy Expenditure:

Energy Expenditure of the participants during the test was calculated with the help the formula i.e., METs x 3.5 x weight in kgs / 200, on the basis of recorded METs value during breath-to-breath analysis.

3.7. STATISTICAL TECHNIQUES EMPLOYED:

In order to determine and analyze the selected physiological variables of selected subjects the collected raw data was analyzed by using descriptive statistical techniques that is mean, SD, minimum and maximum were used and one way Analysis of Variance (ANOVA) was applied to compare the data between the selected groups. If the found 'F' value significant, further Tukey's Post hoc test statistical techniques was used to determine the mean difference, if any. The statistical analysis was performed using of SPSS 28.1 version. The significance was set at 0.05 level.

CHAPTER-IV

ANALYSIS AND INTERPRETATION OF DATA

In the light of set objectives of the study, the data was collected and analysed. The present chapter contains with the analysis of data, findings and discussion of hypothesis.

The purpose of the study was to determine, analyse and compare the selected physiological variables among different sports Persons. To achieve the main purpose of the study total 60 male sports persons were randomly selected from three different sports that is Long Distance Running (n=20), Judo (n=20) and Hockey (n=20). The age of the selected subjects was ranged from 20-24 years.

The statistical techniques descriptive statics i.e., mean, standard deviation (SD) was used to determine the selected physiological variables. The one-way ANOVA was done, whenever significant difference was found on obtained 'F' value, the Tukey post hoc test was applied to determine the mean differences, if any. Further, one way ANOVA was administered to know the difference in the selected physiological variables among sports persons of different sports. Turkey's post hoc test was administered to know the difference between the groups. To analyse the data, level of significance was at 0.05 level

The descriptive statics that is mean and SD of age. Height, Weight and Athletic experience of different sports persons has been showed in table – 4.1

Table 4.1

Mean and SD of Age, Height, Weight and Athletic Experience of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Age (Years)	Height (Cms)	Weight (Kgs)	Athletic Experience (Years)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Long Distance Runners	20	22 ± 1.16	170.7 ± 2.30	57.20 ± 4.69	8 ± 1.12
Judo Players	20	21.95 ± 1.09	170.4 ± 2.01	62.95 ± 8.73	7.8 ± 0.52
Hockey Players	20	22.25 ± 1.48	171.54 ± 2.70	64.6 ± 6.52	7.9 ± 0.30

The table 4.1 denotes that the mean and standard deviation of age, height, weight and athletic experience of Long-Distance Runners, Judo and Hockey players. The mean ±standard deviation Long-Distance Runners, Judo and Hockey players respect to age is 22 ± 1.16, 21.95 ± 1.09 and 22.25 ± 1.48 respectively. The mean ±standard deviation Long-Distance Runners, Judo and Hockey players respect to height is 170.7 ± 2.30, 170.4 ± 2.01and 171.54 ± 2.70 respectively. The mean ±standard deviation Long-Distance Runners, Judo and Hockey players respect to weight is 57.20 ± 4.69, 62.95 ± 8.73 and 64.6 ± 6.52 respectively. The mean ±standard deviation Long-Distance Runners, Judo and Hockey players respect to athletic experience is 8 ± 1.12, 7.8 ± 0.52 and 7.9 ± 0.30 respectively. The graphical representation of Mean and SD of age. Height, weight and athletic experience of different sports persons has been presented in figure – 4.1

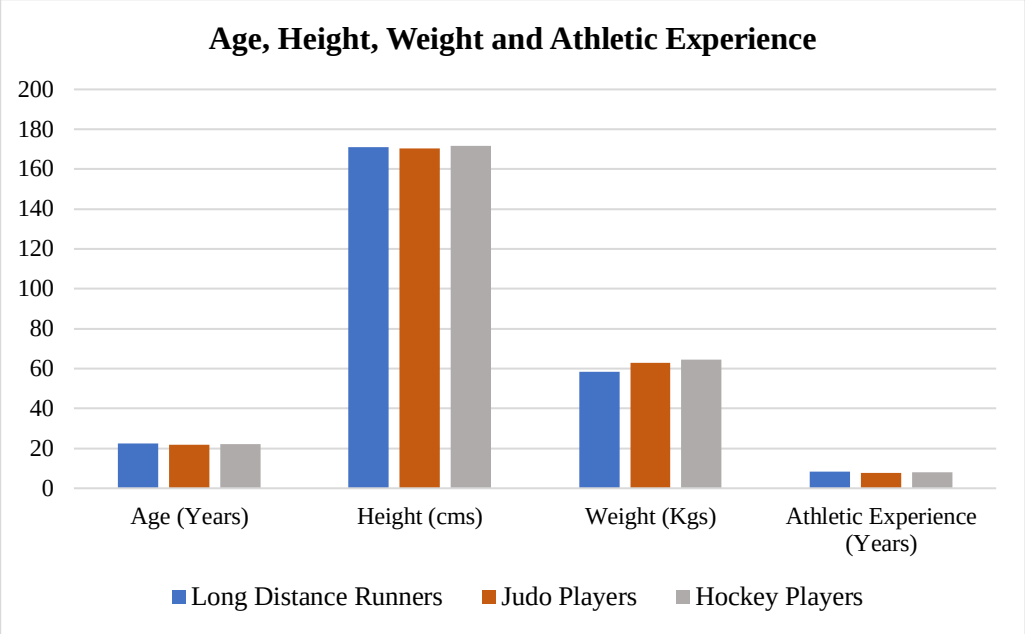

Figure 4.1 – Graphical representation of Mean values of Age, Height, Weight and Athletic Experience of Long-Distance Runners, Judo and Hockey Players.

Objective - 1: To examine and compare the Absolute Peak VO2 of Long-Distance Runners, Judo and Hockey players.

Hypothesis – 1: It was hypothesized that there would be significant difference in Absolute Peak Vo_2 (l/min) among Long-Distance Runners, Judo and Hockey Players.

Descriptive statistics with regard to Absolute Peak Vo2 (ml/min) among Long Distance Runners, Judo and Hockey players have been presented in table – 4.2

Table 4.2

Mean, SD, Minimum and Maximum values of Absolute Peak Vo_2 (ml/min) of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum

Long Distance Runners	20	3639.80	332.93	3047	4258
Judo Players	20	3147.90	479.20	2473	3990
Hockey Players	20	3521	429.29	2625	4314

The table – 4.2 shows the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to Absolute Peak Vo2 (ml/min) as 3639.80± 332.93, 3147.90± 479.20and 3521.00 ± 429.29 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Absolute Peak Vo2 (ml/kg/min) as 3047, 2473and 2625 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Absolute Peak Vo2 (ml/kg/min) as 4258, 3990 and 4314 respectively. The graphical representation of mean scores of Absolute Peak Vo2 has been depicted in figure – 4.2.

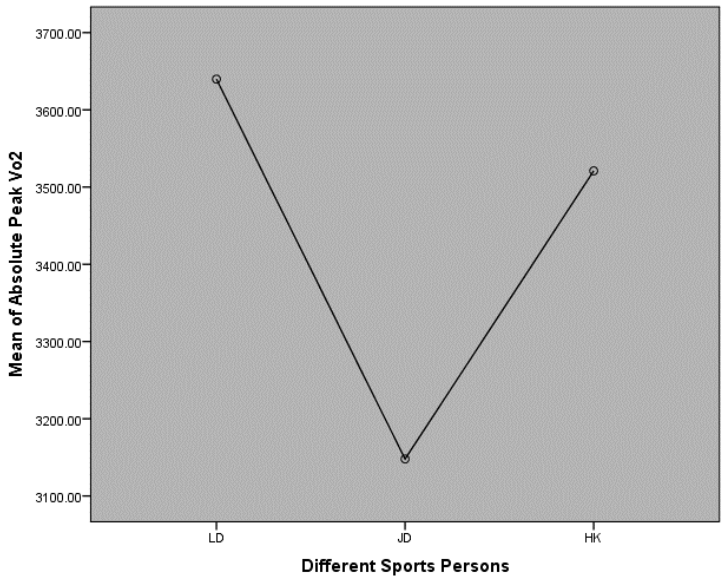

Figure 4.2 – Graphical representation of Mean values of Absolute Peak Vo_2 (ml/min) of Long-Distance Runners, Judo and Hockey Players.

Analysis of Variance (ANOVA) results with regard to Absolute Peak Vo2 (ml/min) among Long Distance Runners, Judo and Hockey players have been presented in table – 4.3

Table 4.3

Analysis of Variance of Absolute Peak Vo_2 (ml/min) of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2635217.73	2	1317608.86	7.53	.001*
Within Groups	9970717	57	174924.86		
Total	12605934.73	59			

* Significant at 0.05 level

It has been observed from table – 4.3 that statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players. Since, the obtained 'F' ratio 7.53 (0.01) was found statistically significant. Therefore, Tukey's Post hoc was applied to find out the degree and direction of differences among selected groups. Result of post hoc test has been presented in table – 4.4.

Table 4.4

Post hoc analysis of Absolute Peak Vo_2 (ml/min) among Long-Distance Runners, Judo and Hockey Players.

Groups (I)	Groups (J)	Mean Difference (I-J)	Std. Error	Sig.
Long Distance Running	Judo	491.9*	132.25	.001
Judo	Hockey	373.1*	132.25	.018
Hockey	Long Distance Running	118.8	132.25	.644

* Significant at 0.05 level

Table 4.4 showed the mean value of Long-Distance Runners was 3639.80 and Judo players was 3147.90 with the mean difference of 491.9. The p-value (Sig.).001 showed ($p<0.05$) significant differences between both the group on the variable Absolute Peak Vo_2 (ml/min). while comparing the mean values the Long-Distance Runners showed higher Absolute Peak Vo_2 than Judo players.

The mean value of Judo players 3147.90 was and Hockey players was 3521 with the mean difference 373.1. The p-value (Sig.).018 showed ($p<0.05$) significant differences between both the group on the variable Absolute Peak Vo_2 (ml/min). while comparing the mean values the Hockey players showed higher Absolute Peak Vo_2 than Judo players.

The mean value of Hockey players was 3521 and Long-Distance Runners was 3639.80 with the mean difference 118.8. The p-value (Sig.) .644 showed ($p<0.05$) no significant differences between both the group on the variable Absolute Peak Vo_2 (ml/min). while comparing the mean values, the Long-Distance Runners showed higher Absolute Peak Vo_2 than Hockey players.

It has been observed that the highest Absolute Peak Vo_2 (ml/min) was recorded in the Long-distance runners than hockey and Judo players. The lowest Absolute Peak Vo_2 (ml/min) were recorded in the Judo players. The absolute value of the maximal oxygen uptake, expressed in litres or millilitres of oxygen per minute, serves as the fundamental unit of measurement. Although body weight has a significant impact on the absolute value of VO2 max, it is more objective and usually accepted to express aerobic capacity in relative values, specifically millilitres per kilogram of body weight per minute.

There was a significance difference found among selected groups related to Absolute Peak Vo_2 (ml/min). Hence, the hypothesis – 1 was accepted.

Objective - 2: To examine and compare the Relative Peak VO2 of Long-Distance Runners, Judo and Hockey players.

Hypothesis – 2: The study was hypothesized that there would be significant difference in Relative Peak Vo_2 (ml/kg/min) among Long-Distance Runners, Judo and Hockey Players. Descriptive statistics with regard to Relative Peak Vo2(ml/kg/min) among Long Distance Runners, Judo and Hockey players have been presented in table – 4.5

Table 4.5

Mean, SD, Minimum and Maximum values of Relative Peak Vo_2 (ml/kg/min) of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	63.53	2.57	58.70	69.60

Judo Players	20	49.98	2.55	45.80	57.10
Hockey Players	20	54.57	4.72	42.00	60.70

The table – 4.5 shows the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to Relative Peak Vo2 (ml/kg/min) as 63.53 ± 2.57, 49.98 ± 2.55 and 54.57 ± 4.72 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Relative Peak Vo2 (ml/kg/min) as 58.70, 45.80 and 42 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Relative Peak Vo2 (ml/kg/min) as 69.60, 57.10 and 60.70 respectively. The graphical representation of mean scores has been depicted in figure – 4.3.

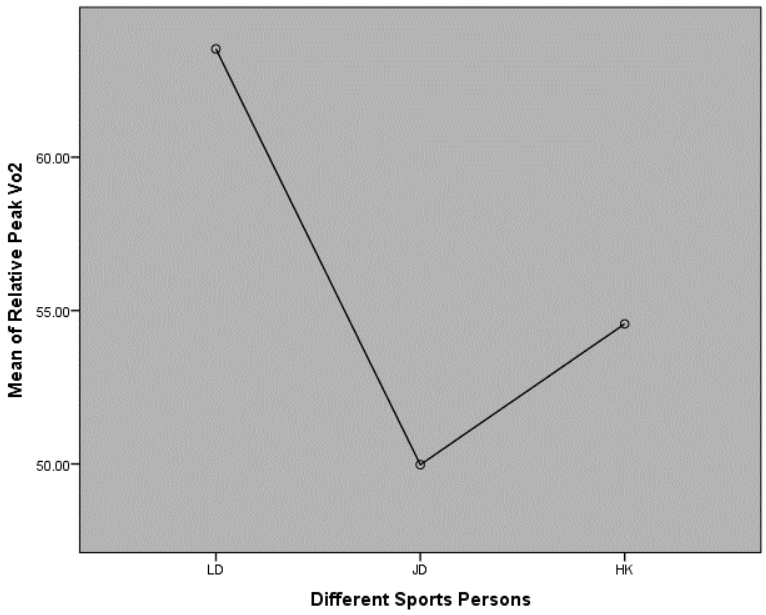

Figure 4.3 – Graphical representation of Mean values of Relative Peak Vo_2 ml/kg/min of Long-Distance Runners, Judo and Hockey Players.

Analysis of Variance (ANOVA) results with regard to Relative Peak Vo2 (ml/kg/min) among Long Distance Runners, Judo and Hockey players have been presented in table – 4.6

Table 4.6

Analysis of Variance (ANOVA) of Relative Peak Vo_2 ml/kg/min of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1901.182	2	950.591	80.604	0.00*
Within Groups	672.225	57	11.793		
Total	2573.407	59			

* Significant at 0.05 level

It has been noticed from table – 4.6 that statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to Relative Peak Vo2 (ml/kg/min). Since, the obtained 'F' ratio 80.604 (0.00) was found statistically significant. Therefore, Tukey's Post hoc was applied to find out the degree and direction of differences among selected groups. Result of post hoc test has been presented in table – 4.7

Table 4.7

Post hoc analysis of Relative Peak Vo_2 (ml/kg/min) among Long-Distance Runners, Judo and Hockey Players.

Groups (I)	Groups (J)	Mean Difference (I-J)	Std. Error	Sig.
Long Distance Running	Judo	13.56*	1.08598	.000
Judo	Hockey	4.59*	1.08598	.000

Hockey	Long Distance Running	8.97*	1.08598	.000

* Significant at 0.05 level

Table 4.7 showed the mean value of Long-Distance Runners was 63.53 and Judo players was 49.98 with the mean difference of 13.56. The p-value (Sig.).000 showed ($p<0.05$) significant differences between both the group on the variable Relative Peak Vo_2 (ml/kg/min). while comparing the mean values the Long-Distance Runners showed higher Relative Peak Vo_2 than Judo players.

The mean value of Judo players 49.98 was and Hockey players was 54.57 with the mean difference 4.59. The p-value (Sig.).000 showed ($p<0.05$) significant differences between both the group on the variable Relative Peak Vo_2 (ml/kg/min). while comparing the mean values the Hockey players showed higher Relative Peak Vo_2 than Judo players.

The mean value of Hockey players was 54.57 and Long-Distance Runners was 63.53 with the mean difference 8.97. The p-value (Sig.).000 showed ($p<0.05$) significant differences between both the group on the variable Relative Peak Vo_2 (ml/kg/min). while comparing the mean values the Long-Distance Runners showed higher Relative Peak Vo_2 than Hockey players.

It has been observed that the maximum Relative Peak Vo_2 (ml/kg/min) was recorded in the Long-distance runners than Hockey and Judo players. The lowest Relative Peak Vo_2 (ml/kg/min) were recorded in the Judo players. This might be because of the subject selected from different sports, the nature or characteristics of the selected sports group is different in terms of movement, physical qualities, skills, dimension of playing areas, work intensities, duration of the events, strategies, training methods, dominant energy system involved etc, the long-distance event is an aerobic nature of activity whereas the hockey comes under aerobic and anaerobic as it requires high repetitive intensive activities with short intermittent recovery periods the sustaining for long duration and judo is the anaerobic activity. But judo players required good aerobic power for the faster recovery between the matches. Because the energy requirement is met by

anaerobic metabolism during high intensity exercise periods while aerobic metabolism gains importance in order to supply homeostatic conditions at recovery intervals. Improvements in aerobic capacity may not only be important for endurance performance, but also for intermittent activities. (Hamilton AL, Nevill ME, Brooks S, at al, 1991, Balsom et.al., 1994, Glaister, 2005, Tomlin and Wenger 2001) Measurement of VO2max has commonly been used to monitor the training status of athletes and can help to determine the training regime and schedules. The oxygen demand is differed from one sport to another. (Singh and Patel, 2014).

The findings of this study were an agreement with the findings of **Singh and Patel (2014),** who have conducted a comparative study on maximum oxygen consumption of different game players. The results showed that the cross-country runners showed highest and judo players had showed lowest VO2 Max among all different sports.

The findings of this study were also agreement with the findings of **Ibikunle and Enumah (2016), Mishra et al., (2015), Oinam and Singh 2019, Singh and Patel, (2014), Rankovic et al., (2010)**, **Degens et al., (2019),** who have found significant difference between different sports with respect to VO_2 Max. Thus, the athletes of different sports demand different VO_2 Max according to the dominant energy system involved in the particular sport.

The Relative Peak Vo_2 (ml/kg/min) found significance difference among Long Distance Runners, Judo and Hockey players. Hence, the hypothesis - 2 was accepted.

Objective 3: To examine and compare the VO_2 at Anaerobic Threshold of Long-Distance Runners, Judo and Hockey players.

Hypothesis – 3: It was also hypothesized that there would be significant difference in VO_2 at Anaerobic Threshold among Long-Distance Runners, Judo and Hockey Players.

Descriptive statistics with regard to Vo_2 at Anaerobic Threshold (ml/min) level among Long Distance Runners, Judo and Hockey players have been presented in table - 4.8

Table 4.8

Mean, SD, Minimum and Maximum values of Vo_2 at Anaerobic Threshold level of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	2520.85	259.84	2046	2895
Judo Players	20	1873.30	378.18	1355	2913
Hockey Players	20	2265.40	328.77	1658	2745

The table – 4.8 shows the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to Vo_2 at Anaerobic Threshold (ml/min) as 2520.85 ± 259.84, 1873.30 ± 378.18 and 2265.40 ± 328.77 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Vo_2 at Anaerobic Threshold (ml/min) as 2046, 1355 and 1658 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Vo_2 at Anaerobic Threshold (ml/min) as 2895, 2913 and 2745 respectively. The graphical representation of mean scores of Vo_2 at Anaerobic Threshold (ml/kg/min) has been depicted in figure – 4.4.

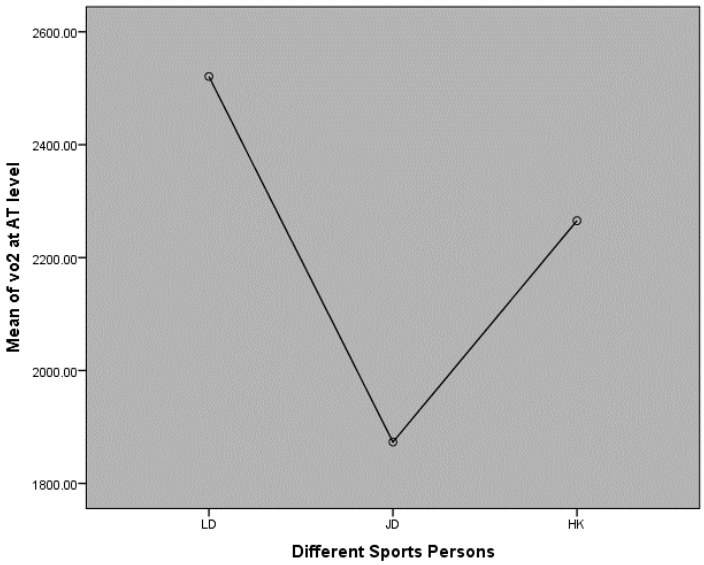

Figure 4.4 – Graphical representation of Mean, Minimum and Maximum values of Vo_2 at Anaerobic Threshold level (ml/min) of Long-Distance Runners, Judo and Hockey Players.

Analysis of Variance (ANOVA) results with regard to Vo_2 at Anaerobic Threshold (ml/min) among Long Distance Runners, Judo and Hockey players have been presented in table – 4.9

Table - 4.9

Analysis of Variance of Vo_2 at Anaerobic Threshold (ml/min) of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	4255454.10	2	2127727.05	20.034	.000*
Within Groups	6053807.55	57	106207.15		
Total	10309261.65	59			

* Significant at 0.05 level

The table 4.9 describes that statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to Vo_2 at Anaerobic Threshold (ml/min). Since, the obtained 'F' ratio 20.034 (0.00) was found statistically significant. Therefore, Tukey's Post hoc was applied to find out the degree and direction of differences among selected groups. Result of post hoc test has been presented in table – 4.10.

Table - 4.10

Post hoc analysis of Vo_2 at Anaerobic Threshold (ml/min) among Long-Distance Runners, Judo and Hockey Players.

Groups (I)	Groups (J)	Mean Difference (I-J)	Std. Error	Sig.
Long Distance Running	Judo	647.55*	103.06	.000
Judo	Hockey	392.1*	103.06	.042
Hockey	Long Distance Running	255.45*	103.06	.001

* Significant at 0.05 level

Table 4.10 showed the mean value of Long-Distance Runners was 2520.85 and Judo players was 1873.30 with the mean difference of 647.55. The p-value (Sig.).000 showed ($p<0.05$) significant differences between both the group on the variable Vo_2 at

Anaerobic Threshold (ml/min). While comparing the mean values the Long-Distance Runners showed higher Vo_2 at Anaerobic Threshold than Judo players.

The mean value of Judo players was 1873.30 and Hockey players was 2265.40 with the mean difference 392.1. The p-value (Sig.).042 showed ($p<0.05$) significant differences between both the group on the variable Vo_2 at Anaerobic Threshold (ml/min). While comparing the mean values the Hockey players showed higher Vo_2 at Anaerobic Threshold (ml/min) than Judo players.

The mean value of Hockey players was 2265.40 and Long-Distance Runners was 2520.85 with the mean difference 255.45. The p-value (Sig.) .001 showed ($p<0.05$) significant differences between both the group on the variable Vo_2 at Anaerobic Threshold (ml/min). While comparing the mean values, the Long-Distance Runners showed higher Vo_2 at Anaerobic Threshold than Hockey players.

It has been detected that the Long-Distance Runners had highest value that is 69.26 % of VO_2 Peak in related to Vo_2 at Anaerobic Threshold followed by Hockey 64.33% of VO_2 Peak and Judo Players 59.51 % of VO_2 Peak.

In all the three selected sports, the Vo_2 at Anaerobic Threshold also plays a vital role to fulfil the demand of the sports at high level. Anaerobic Threshold is considered an important criterion in assessing aerobic endurance. Because of the difference in the metabolic systems in which energy is obtained during exercise, the intensity of exercise corresponding to Anaerobic Threshold must be known for the interpretation of performance and the preparation of the scientific training program. Exercise intensity corresponding to Anaerobic Threshold varies according to the physical conditioning of athlete. (Helgerud et.al.,2001, Wagner 1996). Hence, the Vo_2 at Anaerobic Threshold level was found significantly different in all the three selected sports. Whereas the in long-distance runner and Hockey players were found significantly higher than the Judo players, it is because of the intensive activity is more in long distance and hockey sports as compare to Judo sports. The HIIT training improves the anaerobic threshold level (Sarkar et al., 2019), and Vo_2 at Anaerobic Threshold directly influences and define the performance of different sport performance with other factors (Souza et al., 2018, Mascherini et al., 2010., Zinner et al., (2015).

The significance difference found among Long Distance Runners, Hockey and Judo Players related to Vo_2 at Anaerobic Threshold. Hence, the hypothesis – 3 was accepted.

Objective - 4: To examine and compare the Minute Ventilation (VE) of Long-Distance Runners, Judo and Hockey players.

Hypothesis – 4: The study was also hypothesized that there would be significant difference in Minute Ventilation (VE) among Long-Distance Runners, Judo and Hockey Players.

Descriptive statistics with regard to Minute Ventilation among Long Distance Runners, Judo and Hockey players have been presented in table – 4.11

Table 4.11

Mean, SD, Minimum and Maximum values of VE of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	136.10	10.13	120.40	158.20
Judo Players	20	117.52	11.01	98.00	137.10
Hockey Players	20	107.97	21.38	77.00	138.60

The table – 4.11 depicts the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to Minute Ventilation as 136.10 ± 10.13, 117.52 ± 11.01 and 107.97 ± 21.38 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Minute Ventilation as 120.40, 98 and 77 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Minute Ventilation as 158.20, 137.10 and 138.60 respectively. The graphical representation of mean scores of Minute Ventilation has been depicted in figure – 4.5.

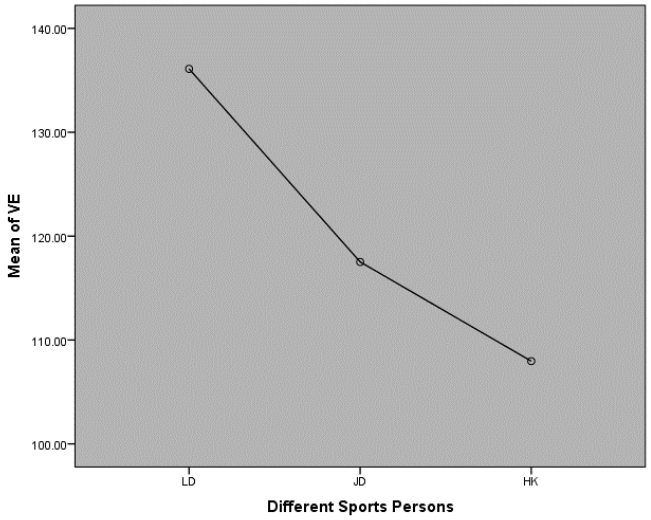

Figure 4.5 – Graphical representation of Mean, Minimum and Maximum values of VE of Long-Distance Runners, Judo and Hockey Players.

Analysis of Variance (ANOVA) results with regard to Minute Ventilation among Long Distance Runners, Judo and Hockey players have been presented in table – 4.12

Table - 4.12

Analysis of Variance of VE of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8187.886	2	4093.943	18.032	.000*
Within Groups	12940.791	57	227.031		
Total	21128.677	59			

* Significant at 0.05 level

The table 4.12 describes that statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to Minute Ventilation. Since, the obtained 'F' ratio 18.032 (0.00) was found statistically significant. Therefore, Tukey's Post hoc was applied to find out the degree and direction of differences among selected groups. Result of post hoc test has been presented in table – 4.13.

Table 4.13

Post hoc analysis of VE among Long-Distance Runners, Judo and Hockey Players.

Groups (I)	Groups (J)	Mean Difference (I-J)	Std. Error	Sig.
Long Distance Running	Judo	18.59*	103.06	.001

Judo	Hockey	9.55	4.76478	.120
Hockey	Long Distance Running	28.12*	4.76478	.000

* Significant at 0.05 level

Table 4.13 explains the mean value of Long-Distance Runners was 136.10 and Judo players was 117.52 with the mean difference of 18.59. The p-value (Sig.).001 showed ($p<0.05$) significant differences between both the group on the variable Minute Ventilation. While comparing the mean values, the Long-Distance Runners showed higher Minute Ventilation than Judo players.

The mean value of Judo players was 117.52 and Hockey players was 107.97 with the mean difference 9.55. The p-value (Sig.).120 showed ($p>0.05$) no significant differences between both the group on the variable Minute Ventilation. While comparing the mean values the Judo players showed higher Minute Ventilation than Hockey players.

The mean value of Hockey players was 107.97 and Long-Distance Runners was 136.10 with the mean difference 28.12. The p-value (Sig.) .000 showed ($p<0.05$) significant differences between both the group on the variable Minute Ventilation. while comparing the mean values, the Long-Distance Runners showed higher Minute Ventilation than Hockey players.

Long distance running is a purely aerobic sports, so the oxygen consumption capacity of players is high as compare to Judo and Hockey players. Hence, the minute ventilation showed high value in Long-distance runners as compare to Judo and Hockey players.

The significance difference found among Long Distance Runners, Hockey and Judo Players related to Minute Ventilation. Hence, the hypothesis – 4 was accepted.

Objective - 5: To examine and compare the Respiratory Exchange Ratio (RER) of Long-Distance Runners, Judo and Hockey players.

Hypothesis- 5: The study was further hypothesized that there would be significant difference in Respiratory Exchange Ratio (RER) among Long-Distance Runners, Judo and Hockey Players.

Descriptive statistics with regard to Respiratory Exchange Ratio (RER) among Long Distance Runners, Judo and Hockey players have been presented in table – 4.14

Table 4.14

Mean, SD, Minimum and Maximum values of Respiratory Exchange Ratio of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	.97	.042	.91	1.04
Judo Players	20	1.02	.031	.94	1.06
Hockey Players	20	.99	.063	.79	1.05

The table – 4.14 depicts the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to RER as .97 ± .042, 1.02 ± .031 and .99 ± .063 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to RER as .91, .94 and .79 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to RER as 1.04, 1.06 and 1.05 respectively. The graphic depiction of mean scores of RER has been represented in figure – 4.6.

Figure 4.6 – Graphical representation of Mean, Minimum and Maximum values of Respiratory Exchange Ratio of Long-Distance Runners, Judo and Hockey Players

Analysis of Variance (ANOVA) results with regard to RER among Long Distance Runners, Judo and Hockey players have been presented in table – 4.15

Table 4.15

Analysis of Variance of RER of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.026	2	.013	5.778	.005*
Within Groups	.128	57	.002		
Total	.154	59			

* Significant at 0.05 level

The table 4.15 explains that statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to RER. Since, the obtained 'F' ratio 5.778 (0.05) was found statistically significant. Therefore, Tukey's Post

hoc was applied to find out the degree and direction of differences among selected groups. Result of post hoc test has been presented in table – 4.16.

Table 4.16

Post hoc analysis of Respiratory Exchange Ratio among Long-Distance Runners, Judo and Hockey Players.

Groups (I)	Groups (J)	Mean Difference (I-J)	Std. Error	Sig.
Long Distance Running	Judo	.051*	.01501	.004
Judo	Hockey	.036	.01501	.099
Hockey	Long Distance Running	.019	.01501	.420

* Significant at 0.05 level

Table 4.16 shows the mean value of Long-Distance Runners was .97 and Judo players was 1.02 with the mean difference of 051. The p-value (Sig.).004 showed ($p<0.05$) significant differences between both the group on the variable RER. While comparing the mean values the Long-Distance Runners showed lessor RER than Judo players.

The mean value of Judo players was 1.02 and Hockey players was .99 with the mean difference .036. The p-value (Sig.).099 showed ($p>0.05$) no significant differences between both the group on the variable RER. while comparing the mean values the Judo players showed higher RER than Hockey players.

The mean value of Hockey players was .99 and Long-Distance Runners was .97 with the mean difference .019. The p-value (Sig.) .420 showed ($p>0.05$) no significant differences between both the group on the variable RER. while comparing the mean values, the Long-Distance Runners showed lessor RER than Hockey players.

The findings of this study were also agreement with the findings of Cipryan et.al., 2017, Ramos-Jimenez et al., 2008 endurance athletes showed lessor RER than sprinters, untrained. The RER indirectly related to the muscle oxidative capacity to get energy for the exercise. Training method and the nature of long-distance running is aerobic, which improves their fat oxidation capacity and RER lower allowing for sports persons to usage lipids more and CHO less, sparing glucose and muscle glycogen. (Bergman and Brooks 1999), hence RER significantly lower in Long Distance Runners than Hockey and Judo.

The significance difference found among Long Distance Runners, Hockey and Judo Players related to Respiratory Exchange Ratio. Hence, the hypothesis- 5 was accepted.

Objective - 6: To examine and compare the Metabolic Equivalents (METs) of Long-Distance Runners, Judo and Hockey players.

Hypothesis-6: Further, it was hypothesized that there would be significant difference in Metabolic Equivalents (METs) among Long-Distance Runners, Judo and Hockey Players.

Descriptive statistics with regard to Metabolic Equivalents (METs) among Long Distance Runners, Judo and Hockey players have been presented in table – 4.17

Table 4.17

Mean, SD, Minimum and Maximum values of Metabolic equivalents of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	18.15	.74	16.80	19.90
Judo Players	20	14.26	.72	13.10	16.30

Hockey Players	20	15.60	1.35	12.00	17.30

The table – 4.17 explains the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to METs as 18.15 ± .74, 14.26 ± 72 and 15.60 ± 1.35 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Metabolic Equivalents as 16.80, 13.10 and 12 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Metabolic Equivalents as 19.90, 16.30 and 17.30 individually. The graphical depiction of mean scores of Metabolic Equivalents has been represented in figure – 4.7.

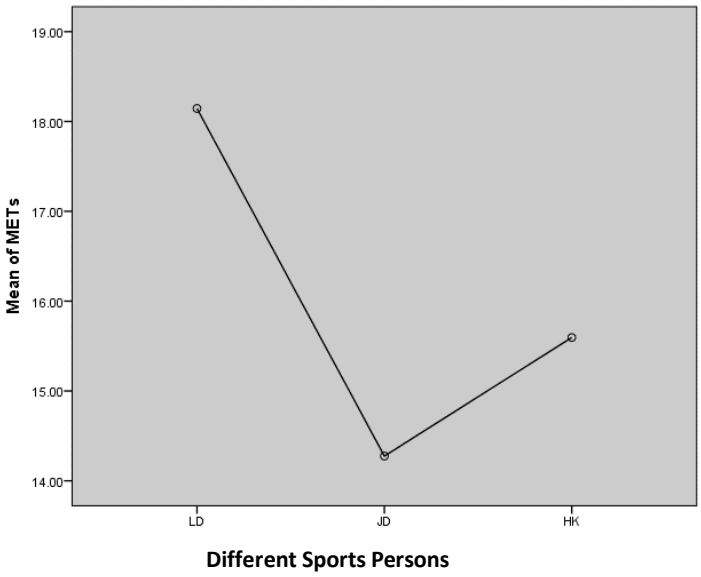

Figure 4.7 – Graphical representation of Mean, Minimum and Maximum values of Metabolic equivalents of Long-Distance Runners, Judo and Hockey Players

Analysis of Variance (ANOVA) results with regard to Metabolic Equivalents among Long Distance Runners, Judo and Hockey players have been presented in table – 4.18

Table 4.18

Analysis of Variance of Metabolic Equivalents of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	154.812	2	77.406	80.636	.000*
Within Groups	54.716	57	.960		
Total	209.529	59			

* Significant at 0.05 level

The table 4.18 clearly shows that statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to Metabolic equivalents. Since, the obtained 'F' ratio 80.636 (0.00) was found statistically significant. Therefore, Tukey's Post hoc was applied to find out the degree and direction of differences among selected groups. Result of post hoc test has been presented in table – 4.19.

Table 4.19

Post hoc analysis of Metabolic Equivalents among Long-Distance Runners, Judo and Hockey Players.

Groups (I)	Groups (J)	Mean Difference (I-J)	Std. Error	Sig.
Long Distance Running	Judo	3.87*	.30983	.000
Judo	Hockey	1.32*	.30983	.000
Hockey	Long Distance Running	2.55*	.30983	.000

* Significant at 0.05 level

Table 4.19 shows the mean value of Long-Distance Runners was 18.15 and Judo players was 14.26 with the mean difference of 3.87. The p-value (Sig.).000 showed ($p<0.05$) significant differences between both the group on the variable Metabolic equivalents. while comparing the mean values the Long-Distance Runners showed higher Metabolic equivalents than Judo players.

The mean value of Judo players was 14.26 and Hockey players was 15.60 with the mean difference 1.32. The p-value (Sig.).000 showed ($p<0.05$) significant differences between both the group on the variable Metabolic equivalents. while comparing the mean values the Judo players showed lessor Metabolic equivalents than Hockey players.

The mean value of Hockey players was 15.60 and Long-Distance Runners was 18.15 with the mean difference 2.55. The p-value (Sig.) .000 showed ($p<0.05$) significant differences between both the group on the variable Metabolic equivalents. while comparing the mean values, the Long-Distance Runners showed higher Metabolic equivalents than Hockey players.

It has been observed that the Long-Distance Runners showed highest Metabolic Equivalent values, followed by Hockey Players and Judo Players. The Metabolic Equivalents has linear relationship with amount of oxygen consumption. In the selected different sports persons' groups, the Long-Distance Runners showed highest value in Peak VO_2 followed by Hockey and Judo Players, hence the Metabolic Equivalents values higher in Long Distance Runners followed by Hockey and Judo Players.

The significance difference found among Long Distance Runners, Hockey and Judo Players related to Metabolic Equivalent. Hence, the hypothesis-6 was accepted.

Objective - 7: To examine and compare the Energy Expenditure of Long-Distance Runners, Judo and Hockey players.

Hypothesis-7: It was further hypothesized that there would be significant difference in Energy Expenditure among Long-Distance Runners, Judo and Hockey Players.

Descriptive statistics with regard to Energy Expenditure among Long Distance Runners, Judo and Hockey players have been presented in table – 4.20

Table 4.20

Mean, SD, Minimum and Maximum values of Energy Expenditure of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	18.17	1.66	15.20	21.30
Judo Players	20	15.74	2.39	12.40	19.90
Hockey Players	20	17.60	2.16	13.10	21.60

The table – 4.20 explains the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to Energy Expenditure as 18.17 ± 1.66, 15.74 ± 2.39 and 17.60 ± 2.16 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Energy Expenditure as 15.20, 12.40 and 13.10 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Energy Expenditure as 21.30, 19.90 and 21.60 respectively. The graphical representation of mean scores of Energy Expenditure has been depicted in figure – 4.8.

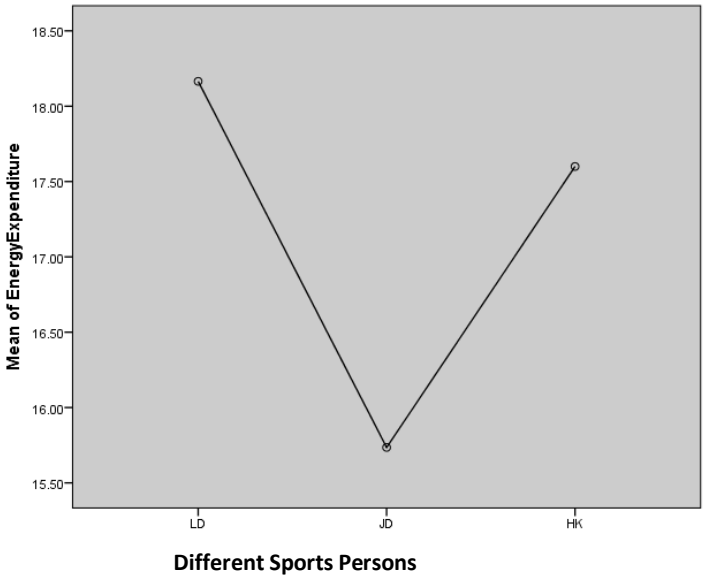

Figure 4.8 - Graphical representation of Mean, Minimum and Maximum values of Energy Expenditure of Long-Distance Runners, Judo and Hockey Players

Analysis of Variance (ANOVA) results with regard to Energy Expenditure among Long Distance Runners, Judo and Hockey players have been presented in table – 4.21

Table 4.21

Analysis of Variance of Energy Expenditure of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	64.682	2	32.341	7.407	.001*
Within Groups	248.871	57	4.366		
Total	313.553	59			

* Significant at 0.05 level

The table 4.21 clearly shows that there was a statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to Energy Expenditure. Since, the obtained 'F' ratio 7.407 (0.001) was found statistically significant. Therefore, Tukey's Post hoc was applied to find out the degree and direction of differences among selected groups. Result of post hoc test has been presented in table– 4.22

Table 4.22

Post hoc analysis of Energy Expenditure among Long-Distance Runners, Judo and Hockey Players.

Groups (I)	Groups (J)	Mean Difference (I-J)	Std. Error	Sig.
Long Distance Running	Judo	2.43*	.66077	.001
Judo	Hockey	1.87*	.66077	.01
Hockey	Long Distance Running	.57	.66077	.671

* Significant at 0.05 level

Table 4.22 shows the mean value of Long-Distance Runners was 18.17 and Judo players was 15.74 with the mean difference of 2.43. The p-value (Sig.).001 showed ($p<0.05$) significant differences between both the group on the variable Energy Expenditure. While comparing the mean values the Long-Distance Runners showed higher Energy Expenditure than Judo players.

The mean value of Judo players was 15.74 and Hockey players was 17.60 with the mean difference 1.87. The p-value (Sig.).01 showed ($p<0.05$) significant differences between both the group on the variable Energy Expenditure. While comparing the mean values the Judo players showed lessor Energy Expenditure than Hockey players.

The mean value of Hockey players was 17.60 and Long-Distance Runners was 18.17 with the mean difference .57. The p-value (Sig.) .671 showed ($p>0.05$) no significant differences between both the group on the variable Energy Expenditure. While comparing the mean values, the Long-Distance Runners showed higher Energy Expenditure values than Hockey players.

It has been observed that the Long-Distance Runners showed highest Energy Expenditure values, followed by Hockey Players and Judo Players. The energy expenditure during exercise is based on the intensity, load, nature of the activity, oxygen uptake and body weight of athletes, with other factors. Hence the selected different sports persons' groups showed difference in energy expenditure values.

The significance difference found among Long Distance Runners, Hockey and Judo Players related to Energy Expenditure. Hence, the hypothesis-7 was accepted.

Objective - 8: To examine and compare the Heart Rate at Anaerobic Threshold of Long-Distance Runners, Judo and Hockey players.

Hypothesis-8: It was hypothesized that there would be significant difference in Heart Rate at Anaerobic Threshold among Long-Distance Runners, Judo and Hockey Players. Descriptive statistics with regard to Heart Rate at Anaerobic Threshold among Long Distance Runners, Judo and Hockey players have been presented in table – 4.23

Table - 4.23

Mean, SD, Minimum and Maximum values of Heart Rate at Anaerobic Threshold of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	151.05	10.32	133	168
Judo Players	20	156.80	9.27	134	172
Hockey Players	20	153.45	10.73	132	171

The table – 4.2 denotes that the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to Heart Rate at Anaerobic Threshold as 151.05 ± 10.32, 156.80 ± 9.27 and 153.45 ± 10.73 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Heart Rate at Anaerobic Threshold as 133, 134 and 132 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Heart Rate at Anaerobic Threshold as 168, 172 and 171 respectively. The graphical representation of mean scores of Heart Rate at Anaerobic Threshold has been depicted in figure – 4.9.

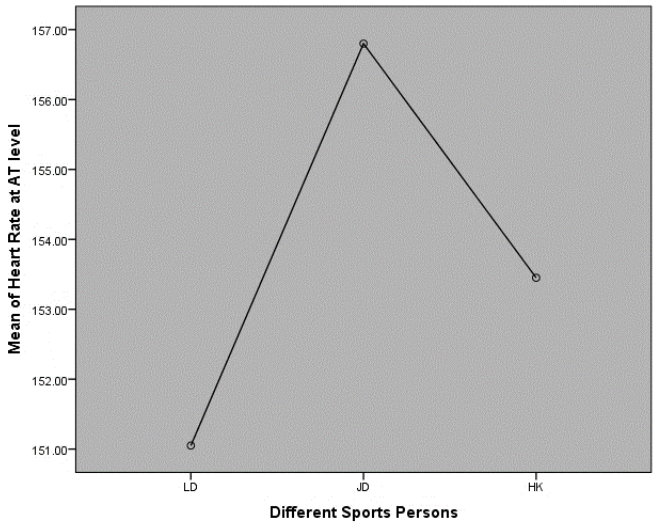

Figure 4.9 – Graphical representation of Mean, Minimum and Maximum values of Heart Rate at Anaerobic Threshold of Long-Distance Runners, Judo and Hockey Players

Analysis of Variance (ANOVA) results with regard to Heart Rate at Anaerobic Threshold (HR at AT) among Long Distance Runners, Judo and Hockey players have been presented in table – 4.23

Table - 4.24

Analysis of Variance of Heart Rate at Anaerobic Threshold of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	333.633	2	166.817	1.626	.206
Within Groups	5847.100	57	102.581		
Total	6180.733	59			

* Significant at 0.05 level

The table 4.24 clearly shows that there were no statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to Heart Rate at Anaerobic Threshold. Since, the obtained 'F' ratio 1.626 (0.206) was not found statistically significant. However, compare the mean value Long Distance Runners shows lessor score and Judo player shows higher value on variable Heart Rate at Anaerobic Threshold (HR at AT). Again, it is because of the demand of the sports.

The result showed that there was no significant difference found between selected groups related to Heart Rate at Anaerobic Threshold. Hence, the hypothesis-8 was rejected.

Objective - 9: To examine and compare the Exercise Heart Rate of Long-Distance Runners, Judo and Hockey players.

Hypothesis-9: It was hypothesized that there would be significant difference in Exercise Heart Rate among Long-Distance Runners, Judo and Hockey Players.

Descriptive statistics with regard to Exercise Heart Rate among Long Distance Runners, Judo and Hockey players have been presented in table – 4.25

Table 4.25

Mean, SD, Minimum and Maximum values of Exercise Heart Rate of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	191.95	4.27	186	198
Judo Players	20	192.85	4.00	189	197
Hockey Players	20	192.30	7.34	172	201

The table – 4.25 depicts that the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to Exercise Heart Rate as 191.95 ± 4.27, 192.85 ± 4 and 192.30 ± 7.34 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Exercise Heart Rate as 186, 189 and 172 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Exercise Heart Rate as 198, 197 and 201 respectively. The graphical representation of mean scores of Heart Rate at Anaerobic Threshold has been depicted in figure – 4.10.

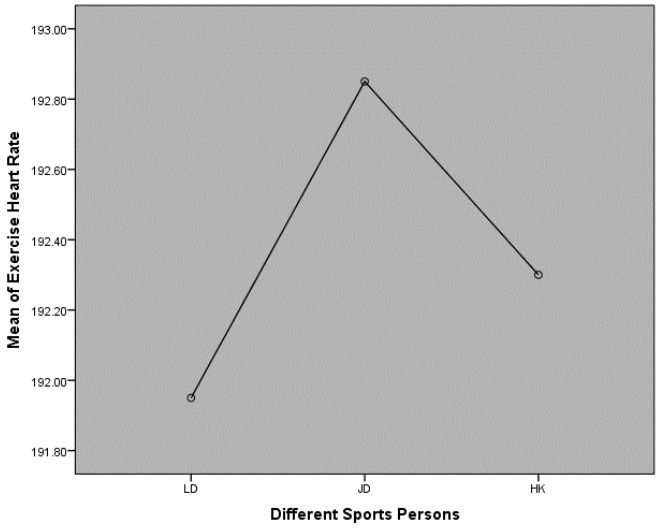

Figure 4.10 – Graphical representation of Mean, Minimum and Maximum values of Exercise Heart Rate Long-Distance Runners, Judo and Hockey Players

Analysis of Variance (ANOVA) results with regard to Exercise Heart Rate among Long Distance Runners, Judo and Hockey players have been presented in table – 4.26

Table 4.26

Analysis of Variance of Exercise Heart Rate of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.233	2	4.117	.140	.870
Within Groups	1675.700	57	29.398		
Total	1683.933	59			

The table 4.26 clearly shows that there were no statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to Exercise Heart Rate. Since, the obtained 'F' ratio .140 (.870) was not found statistically significant. However, compare the mean value Long Distance Runners shows slightly lesser score and Judo player shows slightly higher value on variable Exercise Heart Rate.

All the three sport players followed the protocol with sub maximal workload where the exercise performed at peak level, so the significate difference was not found between different sports persons.

The result showed that there were no statistically significant differences found between selected groups related to Exercise Heart Rate. Hence, the hypothesis-9 was rejected.

Objective - 10: To examine and compare the Recovery Heart Rate of Long-Distance Runners, Judo and Hockey players.

Hypothesis-10: It was also hypothesized that there would be significant difference in Recovery Heart Rate among Long-Distance Runners, Judo and Hockey Players.
Descriptive statistics with regard to Recovery Heart Rate among Long Distance Runners, Judo and Hockey players have been presented in table – 4.27

Table 4.27

Mean, SD, Minimum and Maximum values of Recovery Heart Rate of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	99.35	7.31	92	115
Judo Players	20	111.10	9.89	92	124
Hockey Players	20	102.60	8.13	94	119

The table – 4.27 depicts that the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to Recovery Heart Rate as 99.35 ± 7.31, 111.10 ± 9.89 and 106.85 ± 8.97 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Recovery Heart Rate as 92, 92 and 94 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Recover Heart Rate as 115, 124 and 119 respectively. The graphic depiction of mean scores of Recovery Heart Rate has been represented in figure – 4.11.

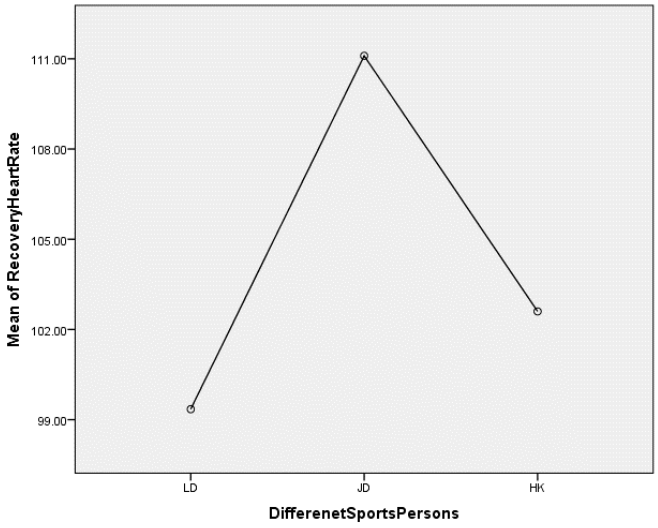

Figure 4.11 – Graphical representation of Mean, Minimum and Maximum values of Recovery Heart Rate Long-Distance Runners, Judo and Hockey Players

Analysis of Variance (ANOVA) results with regard to Recovery Heart Rate among Long Distance Runners, Judo and Hockey players have been presented in table – 4.28

Table 4.28

Analysis of Variance of Recovery Heart Rate of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1472.500	2	736.25	10.15	.000*
Within Groups	4133.15	57	72.51		
Total	5605.65	59			

* Significant at 0.05 level

The table 4.28 shows that statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to Recovery Heart Rate. Since, the obtained 'F' ratio 10.15 (0.00) was found statistically significant. Therefore, Tukey's Post hoc was applied to find out the degree and direction of differences among selected groups. Result of post hoc test has been presented in table – 4.29.

Table 4.29

Post hoc analysis of Recovery Heart Rate among Long-Distance Runners, Judo and Hockey Players.

Groups (I)	Groups (J)	Mean Difference (I-J)	Std. Error	Sig.
Long Distance Running	Judo	11.75*	2.69	.000

Judo	Hockey	8.50*	2.69	.007
Hockey	Long Distance Running	3.25	2.69	.454

* Significant at 0.05 level

Table 4.29 shows the mean value of Long-Distance Runners was 99.35 and Judo players was 111.10 with the mean difference of 11.75. The p-value (Sig.).000 showed ($p<0.05$) significant differences between both the group on the variable Recovery Heart Rate. while comparing the mean values the Long-Distance Runners showed lesser value of Recovery Heart Rate than Judo players.

The mean value of Judo players was 111.10 and Hockey players was 102.60 with the mean difference 8.50. The p-value (Sig.) .007 showed ($p<0.05$) significant differences found between the groups on the variable Recovery Heart Rate. While comparing the mean values the Judo players showed higher Recovery Heart Rate than Hockey players.

The mean value of Hockey players was 102.60 and Long-Distance Runners was 99.35 with the mean difference 3.25. The p-value (Sig.) .454 showed ($p>0.05$) no significant differences between both the groups on the variable Recovery Heart Rate. while comparing the mean values, the Long-Distance Runners showed lesser Recovery Heart Rate than Hockey players.

Because of the type of training, cardiac respiratory adaptation of long-distance runners and Hockey players is good as compare to others. Hence, their recovery is faster as compare to Judo Players.

The significance difference found among Long Distance Runners, Hockey and Judo Players related to Recovery Heart Rate. Hence, the hypothesis-10 was accepted.

Objective - 11: To examine and compare the Oxygen Pulse of Long-Distance Runners, Judo and Hockey players.

Hypothesis-11: Finally, it was hypothesized that there would be significant difference in Oxygen Pulse among Long-Distance Runners, Judo and Hockey Players

Descriptive statistics with regard to Oxygen Pulse among Long Distance Runners, Judo and Hockey players have been presented in table – 4.30

Table 4.30

Mean, SD, Minimum and Maximum values of oxygen pulse of Long-Distance Runners, Judo and Hockey Players.

Name of the Groups	N	Mean	Std. Deviation	Minimum	Maximum
Long Distance Runners	20	18.12	1.55	15.20	20.60
Judo Players	20	13.60	1.69	11.00	16.90
Hockey Players	20	17.17	1.97	14.40	20.60

The table – 4.30 describes that the mean and SD values of Long-Distance Runners, Judo and Hockey players with regard to Oxygen Pulse as 18.12 ± 1.55, 13.60 ± 1.69 and 17.17 ± 1.97 respectively. Minimum value of Long-Distance Runners, Judo and Hockey players with regard to Oxygen Pulse as 15.20, 11 and 14.40 respectively. Maximum values of Long-Distance Runners, Judo and Hockey players with regard to Oxygen Pulse as 20.60, 16.90 and 20.60 respectively. The graphic depiction of mean scores of Recovery Heart Rate has been represented in figure – 4.12.

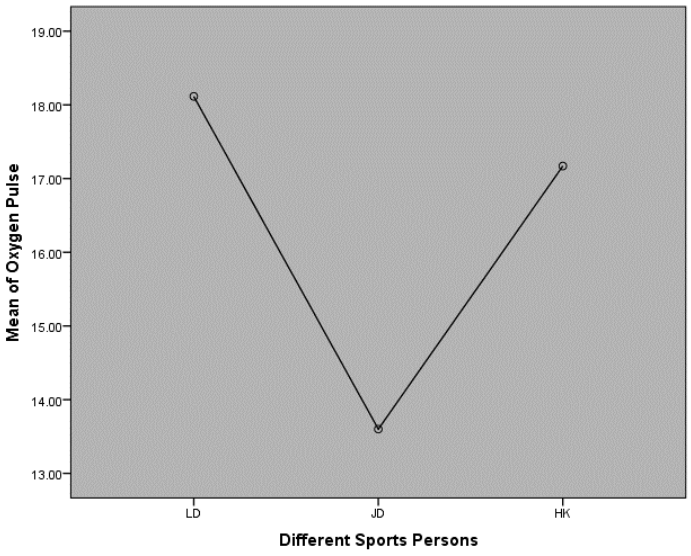

Figure 4.12 – Graphical representation of Mean, Minimum and Maximum values of Oxygen Pulse Long-Distance Runners, Judo and Hockey Players

Analysis of Variance (ANOVA) results with regard to Oxygen Pulse among Long Distance Runners, Judo and Hockey players have been presented in table – 4.31

Table 4.31

Analysis of Variance of Oxygen Pulse of Long-Distance Runners, Judo and Hockey Players.

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	226.821	2	113.411	37.214	.000*
Within Groups	173.708	57	3.048		
Total	400.529	59			

* Significant at 0.05 level

The table 4.32 shows that statistically significant differences ($p<0.05$) existed among Long Distance Runners, Judo and Hockey players with regard to Oxygen Pulse.

Since, the obtained 'F' ratio 37.214 (0.00) was found statistically significant. Therefore, Tukey's Post hoc was applied to find out the degree and direction of differences among selected groups. Result of post hoc test has been presented in table – 4.32.

Table 4.32

Post hoc analysis of Oxygen Pulse among Long-Distance Runners, Judo and Hockey Players.

Groups (I)	Groups (J)	Mean Difference (I-J)	Std. Error	Sig.
Long Distance Running	Judo	4.52*	.55204	.000
Judo	Hockey	3.57*	.55204	.000
Hockey	Long Distance Running	.945	.55204	.210

* Significant at 0.05 level

Table 4.32 shows the mean value of Long-Distance Runners was 18.12 and Judo players was 13.60 with the mean difference of 4.52. The p-value (Sig.).000 showed ($p<0.05$) significant differences between both the group on the variable Oxygen Pulse. while comparing the mean values the Long-Distance Runners showed Higher Oxygen Pulse value than Judo players.

The mean value of Judo players was 13.60 and Hockey players was 17.17 with the mean difference 3.57. The p-value (Sig.).000 showed ($p<0.05$) significant differences between both the group on the variable Oxygen Pulse. While comparing the mean values the Hockey players showed higher Oxygen Pulse than Judo players.

The mean value of Hockey players was 17.17 and Long-Distance Runners was 18.12 with the mean difference .945. The p-value (Sig.) .210 showed ($p>0.05$) no

significant differences between both the group on the variable Oxygen Pulse. while comparing the mean values, the Long-Distance Runners showed Slightly higher Oxygen Pulse than Hockey players.

It has been observed that the Long-Distance Runners showed higher Oxygen Pulse than Hockey and Judo Players. Because skeletal muscle has greater capillarity and mitochondria with increased oxidative capability, there is a larger C(a-v)O2 during exercise. (Roca et.al., 1992). As a result, the aerobically trained athletes show higher Oxygen Pulse.

The significance difference found among Long Distance Runners, Hockey and Judo Players related to Oxygen Pulse. Hence, the hypothesis-11 was accepted.

CHAPTER-V

SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1. SUMMARY:

Identification of the physiological parameters of an athlete in a given sport discipline helps in the player's selection process and identifying athletes' strengths and weaknesses; furthermore, leads to the development of sport-specific training and testing. (Cox MH et.al., 1998). Hence, assessing the status of selected Physiological variables among the different sports person and a careful analysis of assessed each variable may help the coaches and athletes to understand the future performance and fix the target. And also helps the coaches and trainers to train the athletes to their optimal level, to get more advantage of training, and helps to get better result at the earliest.

There are several methods to assess the cardio-pulmonary parameters during exercise, but most relayed method is breath-to-breath analysis method because it gives the best measures of the metabolic response to the exercise. (Albouaini et al., 2007). The Cardio Pulmonary Exercise Testing (CPET) asses the physiological response of the cardiovascular, respiratory, muscular, cellular oxidative system to exercise. (Guazzi, 2017). The CPET assess the intake of oxygen, creation of carbon dioxide and other ventilatory efficiencies during incremental exercises. (Albouaini et al., 2007). The CPET has become a well-accepted method to measure the physiological adaptation to the regular chronic exercise

The purpose of the present study was to determine, analyse and compare the physiological variables of different sports persons. The data obtained from this study will enable to find out whether there are any significant differences in selected physiological variables among different sports persons.

To accomplish the purpose of the study sixty (n=60) different sports persons were selected from three different sports that was, Long Distance Running (LD), (n=20), Judo (JD) (n=20) and Hockey (HK) (N=20). The age of the selected subjects ranged between

20-24 years. The only male subjects were selected for the study. The simple random method was used to select the subject.

The physiological variables selected for the study were Absolute Peak VO_2 (ml/min), Relative Peak VO_2 (ml/kg/min), VO_2 at Anaerobic Threshold, Minute Ventilation, Respiratory Exchange Ratio, Metabolic Equivalents, Energy Expenditure, Heart Rate Anaerobic Threshold, Exercise Heart Rate, Recovery Heart Rate and Oxygen Pulse.

To assess the selected physiological variables such as Absolute Peak VO_2 (ml/min), Relative Peak VO_2 (ml/kg/min), VO_2 at Anaerobic Threshold, Minute Ventilation, Respiratory Exchange Ratio, Metabolic Equivalents, Heart Rate at Anaerobic Threshold, Exercise Heart Rate, Recovery Heart Rate and Oxygen Pulse, the CPET unit with treadmill from COSMED was used. The individual protocol was designed for each subjects according to their fitness level with help of exercise physiology expert. The breath-to-breath analysis was done, the physiological data was recorded for every 30 seconds.

The energy expenditure was assessed by using the formula on the basis of Metabolic Equivalents that is METs X 3.5 X Weight in Kgs /200.

For the analysis of the data descriptive statistics such as Mean, SD, minimum and Maximum and one way ANOVA and turkey's post hoc test was administered with help of SPSS 28.1 software.

5.2.CONCLUSIONS:

On the root of the research assumptions and within the limitation of the study the following conclusions were drawn;

1. Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Absolute Peak VO_2 (ml/min).
2. Significant difference found between Long-Distance Runners and Judo Players on variable Absolute Peak VO_2 (ml/min).

3. Significant difference found between Hockey Players and Judo Players on variable Absolute Peak VO_2 (ml/min).
4. There was no Significant difference found between Long-Distance Runners and Hockey Players on variable Absolute Peak VO_2 (ml/min).
5. The Long-Distance Runners showed higher value related to Absolute Peak VO_2 (ml/min) followed by Hockey and Judo Players.
6. Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Relative Peak VO_2 (ml/kg/min).
7. The Long-Distance Runners showed higher value related to Relative Peak VO_2 (ml/kg/min) followed by Hockey and Judo Players
8. Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to VO_2 at Anaerobic Threshold.
9. The Long-Distance Runners showed higher value related to VO_2 at Anaerobic Threshold (ml/min) followed by Hockey and Judo Players
10. Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Minute Ventilation.
11. Significant difference found between Long-Distance Runners and Judo Players on variable Minute Ventilation.
12. Significant difference found between Long-Distance Runners and Hockey Players on variable Minute Ventilation.
13. There was no Significant difference found between Hockey and Judo Players on variable Minute Ventilation.
14. The Long-Distance Runners showed higher value related to Minute Ventilation followed by Judo and Hockey Players
15. Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Respiratory Exchange Ratio.
16. Significant difference found between Long-Distance Runners and Judo Players on variable Respiratory Exchange Ratio.
17. There was no Significant difference found between Hockey and Judo Players on variable Respiratory Exchange Ratio.

18. There was no Significant difference found between Long-Distance Runners and Hockey Players on Respiratory Exchange Ratio.
19. The Judo players showed higher Value related to Respiratory Exchange Ratio fallowed by Hockey Players and Long-Distance Runners.
20. Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Metabolic Equivalents.
21. The Long-Distance Runners showed higher value related to Metabolic Equivalents followed by Hockey and Judo Players.
22. Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Energy Expenditure.
23. Significant difference found between Long-Distance Runners and Judo Players on variable Energy Expenditure.
24. Significant difference found between Hockey and Judo Players on variable Energy Expenditure.
25. There was no Significant difference found between Long-Distance Runners and Hockey Players on Energy Expenditure.
26. The Long-Distance Runners showed higher value related to Energy Expenditure followed by Hockey and Judo Players.
27. No Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Heart Rate at Anaerobic Threshold.
28. The Judo players showed higher Heart Rate at Anaerobic Threshold fallowed by Hockey Players and Long-Distance Runners.
29. No Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Exercise Heart Rate.
30. The Judo players showed higher Exercise Heart Rate fallowed by Hockey Players and Long-Distance Runners.
31. Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Recovery Heart Rate.
32. Significant difference found between Long-Distance Runners and Judo Players on variable Recovery Heart Rate.

33. Significant difference found between Hockey and Judo Players on variable Recovery Heart Rate.
34. There was no Significant difference found between Long-Distance Runners and Hockey Players on Recovery Heart Rate.
35. The Judo players showed higher Recovery Heart Rate fallowed by Hockey Players and Long-Distance Runners.
36. Significant difference was observed among Long-Distance Runners, Judo and Hockey Players with respect to Oxygen Pulse.
37. Significant difference found between Long-Distance Runners and Judo Players on variable Oxygen Pulse.
38. Significant difference found between Hockey and Judo Players on variable Oxygen Pulse.
39. There was no Significant difference found between Long-Distance Runners and Hockey Players on Oxygen Pulse.
40. The long-Distance Runners showed higher oxygen pulse than Hockey and Judo Players.

5.3. RECOMMENDATIONS:

The investigator made efforts to fulfil the objective of the present study; however, the topic under investigation has a wide scope to add further knowledge in the existing literature. On the basis of the findings and the conclusion drawn, some recommendations were made, which may be of great interest for further academic and research pursuit in the field of sports and physical education.

1. More emphasis should be given to physiological aspects of the athletes. By monitoring the physiological variables, it would be possible to frame the specific training program for the better performance.
2. The present study was recommended that to take consideration of physiological aspects while selecting the sports persons.
3. The study was also recommended that to take consideration of physiological aspects of each individual athletes, while making training schedule for particular event.

4. The present study was recommended to the coaches, trainers and athletes to assess athletes' physiological status required to their specific sport timely, which helps to find out the potential deficiencies if any and to undertake remedial measures to overcome the training stresses.
5. The study suggested utilising CPET to quantify baseline fitness and monitor cardiopulmonary function in athletes who may have cardiovascular or pulmonary disease.
6. It was recommended that similar study may be conducted on female sports persons.
7. It was recommended that similar research may be undertaken on athletes of other different sports.
8. It was also recommended that similar study may be conducted on different age groups.
9. Similar study can be done on sportsmen and non-sportsmen.
10. It was recommended that similar study may be conducted with other type of exercise protocol.
11. A similar study may be done on other variables which have not been used in this study.
12. Similar study may conduct on elite athletes for more accuracy.
13. Further study is needed to determine reference values of CPET for athletes. So, the understanding of the results and performance variances would be exactly quantified.

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